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Surgical management of lung cancer

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'First and foremost we must, as a profession, become more ''carcinoma-minded'' in regard to the lungs'. No-one would disagree, but this statement was made by RC Brock, later Lord Brock, nearly 60 years ago in the British Medical Journal[1]. Carcinoma of the bronchus still remains the most common cancer in men and the second most common cancer in women. In England there are approximately 32 000 deaths from lung cancer per annum[2]. The incidence of lung cancer in males appears at last to be reducing but there is little real evidence of that happening in females. In some groups it is still rising and in Glasgow has even equalled that of breast cancer.

In appropriately selected patients there is no doubt that surgical resection produces the best chance of long-term survival. Spencer Jones, a distinguished chest physician from East Kent wrote, 'The value of surgery for lung cancer has been questioned . . . but without it death for each patient is inescapable . . . Relatives should be left in no doubt that the patient must see a thoracic surgeon if there is any possibility of a surgical resection'[3]. Why? In his study group of patients, of those not treated surgically, 90% were dead in a year and 100% in 26 months. Of the 30 who underwent resection 13 were alive 5 years later. In a large series from the American Armed Forces Central Medical Registry, the overall 5-year survival rate for those having a definitive resection was 49%[4], in a smaller series from England it was 40%[5]. These results are not confined to the young either, as Ishida *et al.*[6] reported a 5-year survival of 48% in patients over 70 and 41% in those aged under 70.

Despite these facts, the UK has one of the lowest resection rates for lung cancer. In 1998/9 there were only 3284 resections for lung cancer in the whole of the United Kingdom[7].

Presentation

Rarely is the disease picked up by chance in an asymptomatic patient. The role of screening, especially using CT is still being debated. Symptoms may be caused by intrathoracic disease, metastases or paraneoplastic syndromes. The most common symptoms are caused by the endobronchial component producing a recalcitrant cough or haemoptysis. Bronchial obstruction may cause distal infection which proves resistant to standard treatment, or breathlessness due to lung collapse. Spread outside the lung within the chest may cause pain or an effusion, again causing breathlessness. Central extension may for example cause nerve palsies, phrenic or recurrent laryngeal. Nodal spread may cause superior vena caval obstruction. The possible modes of presentation are so varied that it really is incumbent on all doctors to consider the disease in all smokers or ex-smokers.

Investigation

The diagnosis of carcinoma of the bronchus should be proven whenever possible by the least invasive technique. Every chest specialist will have experience of patients thought to be dying of lung cancer who have subsequently been found to have a treatable disease such as tubercolosis or lymphoma. Fine needle aspiration (FNA) of metastases has been shown to be simple and reliable[8].The mainstay of investigation though is the plain chest X-ray. Bronchoscopy, now most frequently performed under sedation as an outpatient, is the most common procedure both to establish a diagnosis and to assess operability. It is a safe procedure and can be performed on almost any adult, even the elderly or frail. Of interest is the fact that in 1985 nearly 14 000 diagnostic bronchoscopies were performed by thoracic surgeons, whereas that figure has now fallen to 5287[7], the rest presumably performed by respiratory physicians. If a patient is at all likely to be a surgical candidate a CT scan is mandatory. Enlarged mediastinal nodes revealed by CT scanning should be sampled, traditionally by mediastinoscopy or increasingly frequently by FNA under CT guidance. It is, however, disturbing that

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nearly half the thoracic surgeons in the UK perform neither a mediastinoscopy nor a CT scan[9]. The CT scan should extend down to the adrenal glands as these are common sites for metastases. It is suggested that a bone scan and a brain CT scan should be performed for stage II or III disease[10]. Pleural effusions should be sampled for malignant cells and if necessary a thoracoscopy performed before a patient is deemed inoperable. Some would argue that there is a case for performing a thoracoscopy to assess operability before any lung resection.

If a patient is considered to be fit for lung resection it is important that any apparent contraindication to resection is proven, as false positives are common in the investigation and staging of this disease. Positron emission tomography (PET) is becoming increasingly useful in assessing patients for the presence of metastases. Because of the tumour specificity of PET scanning, it is possible that PET scanning may become the only pre-operative scanning procedure required, making it the most cost-effective method of investigating the disease[11].

Frequently though, it is the general condition of the patient rather than the extent of the disease that precludes surgery. Smoking not only causes lung cancer but chronic obstructive lung disease and cardiovascular disease. There is an increasing group of patients who require both coronary artery grafting and bronchial carcinoma resection and there is debate whether these procedures should be performed synchronously or on separate occasions. The arguments are evenly balanced at present. When assessing pulmonary function prior to lung resection it is necessary to consider what that function will be post-resection, not what it is pre-operatively. Pre-operative quantitative radioactive scans can be helpful.

Staging

The most recent staging scheme is that published by Clifton Mountain in 1997[12]. The outcome of surgery is related to the surgical staging rather than the pre-operative staging. It is thus important to make the pre-operative staging as accurate as possible, but at present PET scanning is the only non-invasive pre-operative staging technique which produces results approximating to the post-surgical results. For example, a clinical stage IIb has a 5-year survival of 24%, whereas the 5-year survival for the same stage post-surgery is 39%, roughly a 50% difference.

Treatment

The common cell types are usually subdivided into non-small cell lung cancer (NSCLC) and small or oat cell cancer, the latter being derived from a different stem cell and generally carrying a much worse prognosis.

Non-small cell lung cancer

Stage 1 and 2 disease should be considered for surgical resection unless there are strong over-riding contra-indications. Problems arise when the disease is classified as stage 3, subdivided into 3a and 3b. Stage 4 is generally considered to be non-surgical. The following contentious issues need to be addressed specifically for non-small cell carcinoma.

Chest wall invasion

Direct invasion of the chest wall by a primary bronchogenic carcinoma is not a contraindication to resection unless there is mediastinal node involvement or other metastatic spread. Shah and Goldstraw report a 5-year survival of 37.2% with an operative mortality of only 3.4%[13]. If there is N2 disease the prognosis is dismal with no patients surviving 5 years[14].

Pancoast tumours

The term Pancoast tumour or Superior Sulcus tumour tends to embrace all apical lung tumours invading the chest wall or pleura, causing pain. Strictly speaking though, it should be reserved for those tumours that occur at the thoracic inlet, producing pain in the distribution of C8, T1 and T2 with an associated Horner's syndrome, rib destruction and possibly vertebral involvement. The lack of strict criteria for including patients in some series has led to a range of successful results being reported. It is, however, still generally held that a combination of pre-operative radiotherapy followed by resection affords the best chance of long-term cure.

Paulson, who popularized the technique, reports a 5-year survival of 44% in those without evident nodal involvement, but no survivors beyond 2 years in the presence of hilar or mediastinal node involvement[15]. However, Sartori *et al.* had a similar 5-year survival of 48% if only the pleura was involved, but this fell to 5.4% in the presence of bone or vascular invasion. Again there were no long-term survivors with N2 disease[16].

Mediastinal node involvement

In the 'new' international staging system, nodal involvement is divided into four stages, N0 to N3. N0 and N1 disease are considered operable with a good prognosis, and N3 inoperable. The controversy relates to N2

disease, i.e. involved ipsilateral mediastinal or subcarinal nodes. The first problem is of definition.

Mediastinal node involvement at multiple levels is classified N2, as is one single positive node. A mass of bulky involved nodes counts the same as a microscopic deposit in one node. The second problem relates to whether the nodes were identified pre-operatively at mediastinoscopy or whether the positive nodes were only discovered at thoracotomy after a negative mediastinoscopy. Pearson first drew attention to the poor prognosis of patients with positive nodes found at mediastinoscopy when out of a carefully selected group of patients only 9% were alive 5 years after surgery[17]. Coughlin reports a group of 339 patients with a positive mediastinoscopy of which 28 came to resection. The projected 5-year survival was 18%[18]. After conventional pre-operative staging, Goldstraw still found that 149 patients out of a total of 578 selected for resection had unsuspected N2 disease[19]. The 5-year survival of those who had a complete resection was 20%. Squamous carcinoma and disease involving only one nodal station had a better prognosis.

Opinion is changing and many surgeons are now selecting out a small subgroup of patients with known N2 disease for resection. What is clear, though, is that an incomplete resection in the presence of N2 disease has appalling results. However, the use of neoadjuvant chemotherapy may change surgical practice further.

Small cell lung cancer (SCLC)

Small cell lung cancer is the most aggressive form of the disease and very few patients ever present at a stage where surgery can be contemplated. Nevertheless, there is a small group who do present with early disease and who, after a thorough search for metastases, should be considered for resection. It is still not clear whether the rare patient with T1NO disease needs chemotherapy. The Toronto Lung Oncology Group have predicted 5-year survival rates of 51% for stage 1 disease, 28% for stage 2 and 19% for stage 3[20].

Prasad reported a series of 97 patients with SCLC in whom the diagnosis was known pre-operatively in 73%. There were 75 pneumonectomies, 21 lobectomies and one wedge excision. Only patients with stage III disease received chemotherapy. The 5-year survival for stage 1 disease was 35%, for stage II, 23% and stage III, 0%. The overall 5-year survival of the group was 17%[21]. The spectre of the MRC study published in 1969 unfortunately still pervades clinical thought about this disease[22]. That study showed only one 5-year survivor in the surgical group and he had had an open and close thoracotomy. The patients were all unstaged by modern techniques and the series has no relevance to modern thoracic surgical practice. It is possible that with the special sensitivity of PET scanning it will be easier in future to identify those patients who do not have metastases.

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Staging lung cancer and the new Mountain classification — multimodality approach

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Staging

Staging of any tumor consists of the determination of the extent of disease. Staging information is important for two reasons: (1) to determine prognosis and (2) to select patients for surgical intervention. The TNM system is widely used to classify lung tumors. In 1986 the staging system was revised based on epidemiologic evidence of improved survival following surgical resection in patients who had previously been classified as having unresectable disease. In the TNM classification, 'T' indicates the features of the primary tumor, 'N' indicates metastases to regional lymph nodes, and 'M' refers to the presence or absence of distant metastases (Tables 1 and 2). In the old (pre-1985) lung cancer classification, stages I and II were considered amenable to surgical management, and stage III tumors were considered unresectable. The revised 1985 system and the current Mountain classification consists of four stages; stage IV includes only those patients with evidence of distant metastases (M1). Stage III has been redefined and divided into stages IIIA and IIIB. Of these two categories, stage IIIB is also considered inoperable disease. In the previous classification, tumors with limited

Table 1 TNM descriptors

Primary tumor (T)	
TX	Primary tumor cannot be assessed, or tumor proven by the presence of malignant cells in sputum or bronchial washings but not visualized by imaging or bronchoscopy.
T0	No evidence of primary tumor.
Tis	Carcinoma in situ.
T1	Tumor 3 cm in greatest dimension, surrounded by lung or visceral pleura, without bronchoscopic evidence of invasion more proximal than the lobar bronchus* (i.e. not in the main bronchus).
T2	Tumor with any of the following features of size or extent: >3 cm in greatest dimension. Involves main bronchus, 2 cm distal to the carina. Invades the visceral pleura. Associated with atelectasis or obstructive pneumonitis that extends to the hilar region but does not involve the entire lung.
T3	Tumor of any size that directly invades any of the following: chest wall (including superior sulcus tumors), diaphragm, mediastinal pleura, parietal pericardium; or tumor in the main bronchus <2 cm distal to the carina, but without involvement of the carina; or associated atelectasis or obstructive pneumonitis of the entire lung.
T4	Tumor of any size that invades any of the following: mediastinum, heart, great vessels, trachea, esophagus, vertebral body, carina; or tumor with a malignant pleural or pericardial effusion,† or with satellite tumor nodule(s) within the ipsilateral primary-tumor lobe of the lung.
Regional lymph nodes (N)	
TX	Regional lymph nodes cannot be assessed.
N0	No regional lymph node metastasis.
N1	Metastasis to ipsilateral peribronchial and/or ipsilateral hilar lymph nodes, and intrapulmonary nodes involved by direct extension of the primary tumor.
N2	Metastasis to ipsilateral mediastinal and/or subcarinal lymph node(s).
N3	Metastasis to contralateral mediastinal, contralateral hilar, ipsilateral or contralateral scalene, or supraclavicular lymph node(s).
Distant metastasis (M)	
MX	Presence of distant metastasis cannot be assessed.
M0	No distant metastasis.
M1	Distant metastasis present.‡

*The uncommon superficial tumor of any size with its invasive component limited to the bronchial wall, which may extend proximal to the main bronchus, is also classified T1.
†Most pleural effusions associated with lung cancer are due to tumor. However, there are a few patients in whom multiple cytopathologic examinations of pleural fluid show no tumor. In these cases, the fluid is non-bloody and is not an exudate. When these elements and clinical judgment dictate that the effusion is not related to the tumor, the effusion should be excluded as a staging element and the patient's disease should be staged T1, T2, or T3. Pericardial effusion is classified according to the same rules.
‡Separate metastatic tumor nodule(s) in the ipsilateral non-primary-tumor lobe(s) of the lung are also classified M1.

Table 2 Stage grouping — TNM subsets

Stage	TNM subset
0	Carcinoma in situ
IA	T1N0M0
1B	T2N0M0
IIA	T1N1M0
IIB	T2N1M0
	T3N0M0
IIIA	T3N1M0
	T1N2M0
	T2N2M0
	T3N2M0
IIIB	T4N0M0
	T4N1M0
	T4N2M0
	T1N3M0
	T2N3M0
	T3N3M0
	T4N3M0
IV	Any T Any N Any M1

Staging is not relevant for occult carcinoma, designated TXN0M0.

invasion of the chest wall and mediastinum were included in this inoperable category, but under the new classification such tumors are considered to be potentially operable provided that vital structures in the mediastinum such as the great vessels, heart, and aerodigestive tract are not involved. The designation T4 is now used to describe lesions with extensive invasion of the mediastinum or diaphragm. In addition, in the current system patients with ipsilateral nodal metastases are also considered operable. However, for the most part, only patients with limited ipsilateral mediastinal nodal disease fall into the operable category. These are usually cases in which the tumor is contained within the capsule of the lymph nodes, and is limited to involvement of the lower mediastinal nodes. The category N3 was added to the TNM staging to refer to contralateral mediastinal or hilar lymph node or supraclavicular lymph node metastases. N3 disease is considered to be in the non-surgical or unresectable category.

In 1997 further revisions were introduced into the staging grouping of the TNM subsets in the International System for Staging Lung Cancer. This was adopted by the American Joint Committee on Cancer and the Union Internationale Contre le Cancer. There are very minor alterations in the previous classification. Stage I has been divided into two groups, IA and IB. T4 has also been slightly redefined to include satellite tumor nodule(s) within the ipsilateral primary lobe of the lung. Previously any additional nodules had been considered evidence of distant metastatic disease (M1). The definition of stages IIA, IIB, IIIA, and IIIB are included in Table 2. In regard to stage I, data have consistently shown a better outcome for patients with T1N0M0 lung tumors than for any other subsets. Survival is estimated to be approximately 60% in patients with clinical stage IA disease and only 38% for the those in clinical stage IB. Stage IB is designated as patients with T2 tumors. Regarding stage II, the survival rate for patients with T1N1M0 disease, that is, T1 lesions with involved hilar nodes is higher than those with T2N1M0 disease. However, the former is a small group and rather infrequent. In regard to stage III, definitions for stage IIIA and IIIB are provided in Table 2.

Computed tomography

A number of different imaging modalities have historically been used in staging lung cancer. These have included standard and conventional tomography as well as computed tomography and magnetic resonance imaging. In some instances, accurate staging and the determination of appropriate treatment for patients with lung cancer can be made non-invasively with imaging modalities alone, although in most instances some degree of surgical staging is also necessary. Computed tomography has now become the major imaging modality of choice in the evaluation of patients with bronchogenic carcinoma. Computed tomography is not only useful for staging but also as a guide to surgical management and in the determination of appropriate methods for surgical staging.

Evaluation of the primary tumor (the T factor)

T3 tumors include tumors of any size with direct extension into the chest wall, diaphragm, the mediastinal pleura or pericardium without involvement of the heart, great vessels, trachea, esophagus, or vertebral body. T4 tumors are tumors of any size with invasion of the mediastinum or involvement of the heart, great vessels, trachea, esophagus, vertebral body, carina, or with associated malignant pleural effusion.

It is not always possible to distinguish T3 from T4 lesions with imaging studies. Lesions with chest wall invasion are classified as T3 lesions and are potentially resectable. Surgical resection, however, requires en bloc resection of the pulmonary malignancy and the contiguous chest wall and is associated with an operative mortality in the range of 8–15%. It is always desirable, therefore, to determine pre-operatively if chest wall invasion is present, in order to select patients as operative candidates. The value of CT in the determination of chest wall invasion is somewhat limited. Although CT certainly provides incremental information over standard films, many of the findings described in the literature which are said to be associated with chest wall invasion have been shown to be neither sensitive nor specific. These include pleural thickening adjacent to the tumor, encroachment or increased density of pleural fat or an obtuse angle between the pulmonary mass and the pleural surface. Only the presence of a mass in the chest

wall or definite rib destruction are helpful indicators of chest wall invasion. Magnetic resonance imaging has been shown to be more accurate than CT in defining the extent of chest wall invasion and particularly in the evaluation of superior sulcus carcinomas.

Similarly, CT may be useful when extensive mediastinal invasion is present. Contrast-enhanced images may show vascular encasement and involvement of major mediastinal organs. However, CT is unable to distinguish contiguity of tumor with the mediastinum in some instances from actual invasion of the walls of vital mediastinal structures. Again, MR imaging has been shown to be more accurate than CT in delineating the extent of malignant invasion.

Evaluation of nodal metastases (the N factor)

Computed tomography has become the method of choice for the assessment of mediastinal nodes in bronchogenic carcinoma. Previously patients with mediastinal nodal metastases from bronchogenic carcinoma were not considered to benefit from surgical therapy. However, numerous studies have consistently documented improved survival of selected patients after resection of mediastinal nodal disease and in most cases adjuvant radiation therapy. The new American Joint Committee on Cancer Staging now considers patients with ipsilateral mediastinal lymph node metastases (N2) as potentially surgically resectable stage IIIA disease. Included in this group are patients with (a) intracapsular rather than extracapsular involvement and (b) positive nodes identified at thoracotomy after negative mediastinoscopy. In addition, early reports have indicated that even patients with gross and bulky ipsilateral nodal metastases (N2) may benefit from surgery if it is combined with neoadjuvant chemotherapy and radiation therapy. However, patients with contralateral mediastinal nodal involvement (N3) are considered to have inoperable stage IIIB disease.

Several studies have addressed the accuracy of CT in the staging of mediastinal nodal metastases in lung cancer. Some early investigations reported a high sensitivity in the range of 88–94%, values that are equivalent to the sensitivity of mediastinoscopy. Opinions based on such data suggested that mediastinoscopy was unnecessary in cases in which the CT scan showed no evidence of enlarged nodes. However, the results in many of these early studies differed widely and are difficult to interpret for several reasons. The variant results may be explained by differences in size and nature of the patient group studied, the frequency of mediastinal lymph node involvement, the size criteria used to distinguish normal from abnormal nodes, and most importantly the method used for surgical correlation with radiographic findings. Surgical evaluation of mediastinal nodes was limited in most cases to node palpation rather than to complete nodal sampling and biopsy. In addition, lack of an adequate lymph node mapping scheme did not allow for strict correlation of abnormal nodes detected at CT with specific nodal groups sampled at thoracotomy and mediastinoscopy. More recent studies, which have employed total nodal sampling and the ATS lymph node classification, have shown a lower sensitivity for CT in the detection of nodal metastases. McLoud *et al.* reported that the sensitivity and specificity of CT were 64% and 62% respectively in a study which used 1 cm as the upper limit of normal diameter for the short axis of lymph nodes and also employed extensive lymph node sampling that was correlated closely with CT nodal stations. The limitations of CT in the identification of N2 and N3 disease are now well accepted. MR imaging is constrained by similar limitations and there appears to be no clear advantage to MR imaging over CT in identifying lymph node involvement by tumor.

Despite the limitations of CT in staging mediastinal lymph nodes, this imaging modality does provide important information concerning the nodal status of patients with lung cancer. Identification and localization of enlarged lymph nodes aids in the selection of the appropriate invasive procedure for surgical staging. Evidence of extensive lymphadenopathy with secondary signs such as obstruction of the superior vena cava or destruction of the vertebral bodies may preclude further need for staging procedures if the histologic characteristics of the primary lesion are known.

A negative CT scan for mediastinal adenopathy is a more controversial issue. It is the opinion of this author that such patients still merit mediastinoscopy because of the limitations of CT. However, in some institutions mediastinoscopy may not be available or preferred. If patients are selected immediately for thoracotomy without precedent mediastinoscopy careful nodal sampling must be done at the time of surgery. Because of the low specificity of CT, enlarged lymph nodes must be biopsied before surgery. Enlarged hyperplastic nodes occur frequently in the setting of central tumors associated with obstructive pneumonitis. Various procedures are available for such sampling, including mediastinoscopy, Wang needle biopsy, and percutaneous needle biopsy.

The issue of CT staging of the mediastinum in T1 lesions is controversial. T1 tumors are defined as lesions 3 cm or less in greatest diameter surrounded by lung or visceral pleura without evidence of invasion proximal to the lobar bronchus. Several studies have suggested a low prevalence of mediastinal nodal metastatic disease with T1 cancers (5–15%). Because of such a low prevalence, it has been suggested that CT may not be necessary in such patients and that the pre-operative staging should be limited to plain chest radiographs. However, Seely *et al.* in a study of 104 patients with T1 lesions found a higher prevalence of nodal metastases (21%). The sensitivity of CT in this study was 77%. The high prevalence of metastases to the mediastinum suggests the need for further careful pre-operative staging in such patients, which will include CT scanning.

Evaluation of distant metastases (the M factor)

The role of imaging in the determination of extrathoracic metastases from bronchogenic carcinoma is somewhat controversial. CT and MR may be useful in the detection of silent brain metastases in patients with adenocarcinoma. Because the adrenal glands are one of the most common sites for extrathoracic metastases, CT scans used in staging lung cancer should include the upper abdomen. In a study by Salvatierra *et al.* of 146 patients with lung cancer there was a 7.5% prevalence of adrenal metastases. Examination of the adrenal glands and, in fact, the liver can be done easily at the time of the CT examination of the chest. However, two-thirds of adrenal masses identified by CT in patients with lung carcinoma are non-neoplastic. Adrenal adenomas are quite common. Most adrenal adenomas are less than 3 cm in diameter and often are of low attenuation (less than 10 Hounsfield Units) because of their fat content. However, in lesions not meeting these criteria, needle aspiration biopsy of the adrenal may be necessary.

Conclusion

Computed tomography remains the imaging method of choice in the staging of bronchogenic carcinoma. Despite its limitations, CT is still indicated in order (1) to determine the extent of the primary lesion; (2) to evaluate the mediastinum for the presence of nodal metastases; and (3) to screen for metastatic disease in the adrenal glands.

MR

Initial experience suggests that evaluation of the mediastinum with MR is approximately equal to that of CT with regard to the staging of bronchogenic carcinoma. These data, however, are somewhat limited. Webb *et al.* reported a series of 33 patients in which they compared staging with MR with staging done with computed tomography and surgery. They found that CT and MR provided comparable information regarding the presence and size of mediastinal lymph nodes. MR better discriminated mediastinal nodes from vascular structures when compared with non-contrast CT. However, in two of their 11 patients with multiple mediastinal lymph nodes that were normal in size at CT examination and surgery, MR suggested a confluent abnormal mass probably because of poorer spatial resolution. Musset *et al.* studied 44 patients with bronchogenic carcinoma prospectively by both computed tomography and magnetic resonance imaging. Both T1- and T2-weighted sequences and coronal and sagittal images were performed. They found no statistically significant differences between the two imaging methods in the evaluation of either tumor extent or nodal involvement. Their experience was similar to that of other investigators who reported that calculation of the relaxation times, T1 and T2 are not useful in distinguishing benign from malignant adenopathy. MR, however, may be useful in the assessment of T3 lesions, that is, lesions that directly invade the chest wall and mediastinum. In a recent report, Haggar *et al.* reported that MR imaging was useful in the evaluation of chest wall invasion by carcinoma of the lung. They studied 19 patients, 13 of whom underwent surgery. MR findings indicative of chest wall invasion included a high signal focus within the chest wall and/or chest wall thickening on T2-weighted images. TR values at 2500 ms and TE values at 50–100 ms were employed. Contrast differences between normal and invaded chest wall could be appreciated on these T2-weighted images, and coronal and sagittal imaging facilitated identification of tumor contiguity with extrathoracic structures.

Webb *et al.*, in a study comparing results of CT with magnetic resonance imaging in 170 patients with bronchogenic carcinoma, found little difference in the sensitivity, specificity, and accuracy of CT and MR in the evaluation of mediastinal adenopathy. However, he also reported an increased ability of MR to detect both chest wall and mediastinal invasion.

Superior sulcus carcinomas are defined as bronchogenic carcinomas occurring at the extreme apex of the lung. Such tumors may be considered resectable and are usually managed with radiation therapy followed by surgery with chest wall resection if there is no evidence of mediastinal or distant metastases. However, accurate assessment of the local extent of disease is an important aspect in the staging of these lesions. We have found MR to be useful in determining certain parameters of unresectability such as invasion of the vertebral body and involvement of the subclavian artery and brachial plexus. Sagittal and coronal images are particularly useful in imaging such lesions. T2-weighted images help to differentiate apical tumor from surrounding muscle and to define the extent of the tumor in the base of the neck.

MR is a useful technique in evaluating the mediastinum. It is most advantageous in the diagnosis of mediastinal vascular lesions. It is also useful in the evaluation of mediastinal masses, although the spatial resolution is less than that observed on CT scanning.

The role of PET in lung cancer

Positron emission tomography (PET) with FDG, a d-glucose analog labeled with positron-emitting fluorine-18 has become a useful imaging modality in evaluating patients with lung cancer. PET takes advantage of one characteristic feature of malignant cells, increased glucose metabolism. Because tumors are metabolically active, tumor cells take up an increased amount of FDG relative to normal lung tissue. In regard to the staging of lung cancer, in several studies up to 18% of

patients considered to be resectable will have more advanced disease demonstrated by PET and become non-resectable.

PET is particularly helpful in staging nodal disease. PET has been shown to be more sensitive and specific than CT with accuracy reported to be 81–100%. In one study, PET correctly increased or decreased nodal staging as determined by CT in 24% of pre-surgical patients. PET reduces the probability that patients with unresectable mediastinal nodal metastases will undergo an attempt at curative resection.

PET also appears to improve the non-invasive detection of extrathoracic disease. Whole body PET has the capability to stage both inter- and extrathoracic disease in a single examination and has an overall greater accuracy than conventional imaging. Whole body FDG PET alters management in up to 40% of cases.

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